Watershed Assessment Model
GIS Application
User Guide

Prepared For

Foothills Model Forest
Hinton, Alberta

June 1997

The Forestry Corp

Watershed Assessment Model

User Guide

June 11, 1997

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foothills
model *forest*
a growing understanding

Foothills Model Forest is one of eleven Model Forests that make up the Canadian Model Forest Network. As such, Foothills Model Forest is a non-profit organization representing a wide array of industrial, academic, government and non-government partners, and is located in Hinton, Alberta. The three principal partners representing the agencies with vested management authority for the lands that comprise the Foothills Model Forest, include Weldwood of Canada (Hinton Division), the Alberta Department of Environmental Protection and Jasper National Park. These lands encompass a combined area of more than 2.75 million hectares under active resource management.

The Canadian Forest Service of Natural Resources Canada is also a principal partner in each of the eleven Model Forest organizations and provides the primary funding and administrative support to Canada's Model Forest Program.

The Foothills Model Forest mission: "We are a unique community of partners dedicated to providing practical solutions for stewardship and sustainability of our forest lands."

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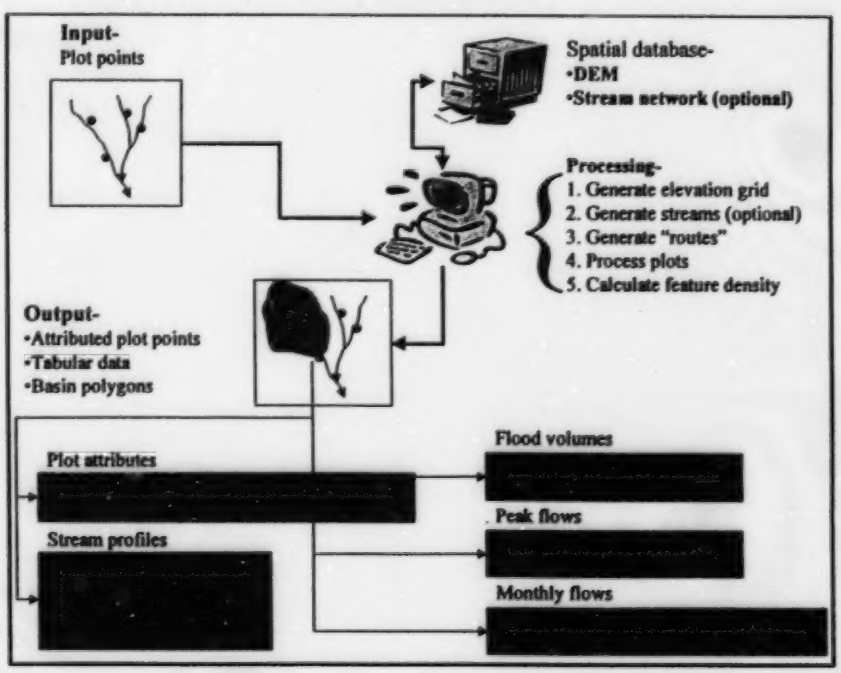
1.0 Overview

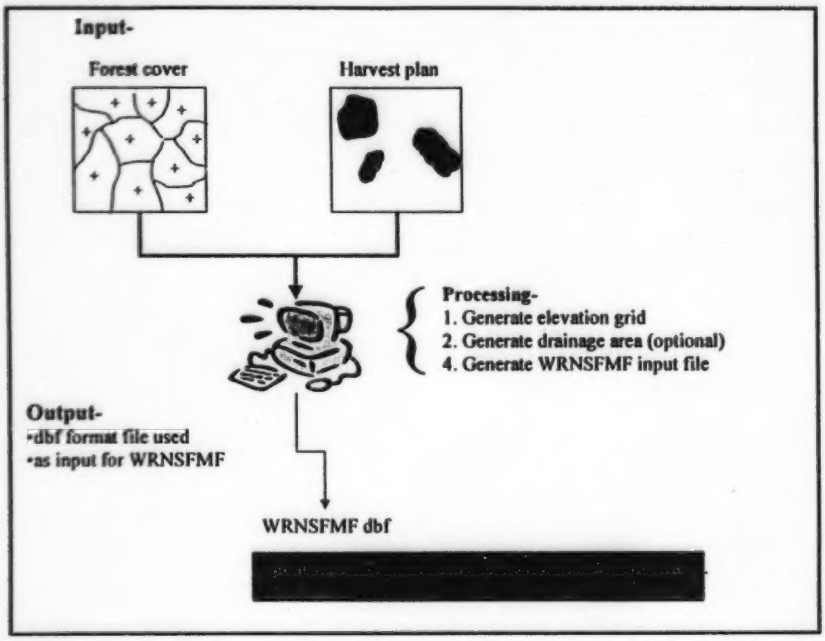
1.1 Introduction

The Watershed Assessment Model (WAM) is a GIS application which generates watershed and stream characteristics from existing digital point, DEM (digital elevation model), and stream network information. It is also capable of generating datasets in a format compatible with the WRNSFMF application for evaluating annual water yield changes.

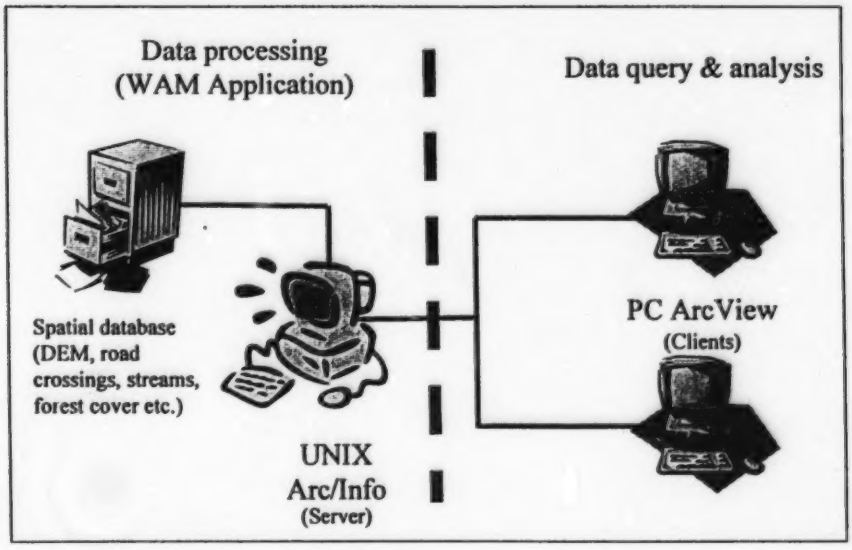
Stream and watershed characteristic calculation overview –



WRNSFMF dataset creation overview



WAM is structured in a client-server framework meaning that the GIS application runs in ArcInfo on a UNIX processing server and is strictly written for data processing. The resultant data is viewed and queried using ESRI's desktop GIS software ArcView.



The processing aspect of the application is targeted at persons familiar running custom applications on the UNIX platform, and with knowledge of the GIS file structures. More importantly, end users of the output data must have a good understanding of the source of the input datasets and the applicability of the results in watershed, streams, and forest resource management. This document addresses the issues relating to data and gives detailed descriptions on how to use the application.

1.2 Data Requirements

For WAM processing, stream and watershed attributes are calculated from points. The points must be stored as an ArcInfo coverage. This coverage does not necessarily have to represent actual points on the ground, they can also be hypothetical points which may, for example, represent planned road crossing locations. A corrected streams network is a requirement to run the application, but there are also tools in place to generate this dataset. See the section 2.2.2 for more information on the required streams network. DEM data is also a required dataset, but it's availability and structure are transparent to the user therefore there is little related information in the User Guide. Please refer to the WAM System Guide for information on DEM requirements.

For the creation of the WRNSFMF dataset, the input formats are considerably more rigid. The following Arc/Info polygon coverages are required for generating a WRNSFMF dataset;

- Forest cover
- Harvest plan
- Historical cuts

Each of these coverages requires specific item names describing the spatial features represented in them. Section 4.3.2 describes the required field names.

1.3 How To Use This Guide

Section 2.0 of this guide gives the user the necessary background on application input, output and processing. Section 3.0 describes how to launch the application and provides additional background on the interface environment. Section 4.2 and 4.3 on process flow illustrate the required steps, input data, and processing order for both the WAM and WRNSFMF processing. Section 4.4 describes the output from both these processes. Section 3.0 describes again the process flow and then illustrates each associated menu and how it is used.

Resultant dataset descriptions are listed in the "Output Data Description" and the data structures are listed in Appendix A.

2.0 Application Background

2.1 Introduction

The WAM application is unique and complex in terms of the approach taken to extract watershed information from a spatial database. Recognizing that corrected stream network data may not be available for use with the application, functions were incorporated into the application to generate this dataset. The combination of uniqueness, complexity, and incomplete input datasets introduces several issues that the user of the application and more importantly the user of the output data must be aware of. These issues are discussed in this section.

2.2 Data Issues1.0 Overview

2.2.1 Digital Elevation Data

Most of the calculations performed in the application are entirely dependent on the resolution and accuracy of the DEM data. DEM data in Alberta can be purchased at several different fixed grid resolutions (the actual points representing elevations can be at a 25, 50 or 100 meter spacing). The grid of points is derived from a combination of measured ground points and interpreted ground points. The two data sources are combined to mathematically interpolate a surface model at the requested resolution. Thus the user must be aware that the points in the DEM rarely represent the exact location of measured points, and the number of measured points is usually a small percentage of the actual number of points in the DEM grid. On the other hand though, this is the most current province-wide data available and is no less accurate than contour data collected at a similar scale.

2.2.2 Corrected Streams Network

The WAM application requires a corrected streams network for most stream and fisheries related analysis. As the majority of users do not have these data available to them, there are functions in the application to create such a network solely from DEM data using ArcInfo Grid functions. Therefore the generated network is entirely dependant on the accuracy of the DEM. During testing it was found that generated streams differed in varying degrees from interpreted streams in density and relative location. The resulting streams network is affected by three factors; original DEM data resolution, terrain variability, and grid cell size. Grid cell size will be discussed in section 2.3.2.

As discussed in section 2.2.1, DEM data is available in several different resolutions. Stream networks generated using for example, 100 meter resolution data will be less dense as any streams with a width less than the cell size may not being recognized.

During the testing of the WAM application varying success was achieved in streams generation based on terrain variability in two different areas in Alberta. Areas with considerable variability (Tri-Creeks), produced streams very similar to those of the 1:20000 interpreted base data, while in very flat areas (Red Earth Creek) the resulting streams were incorrect. These results were, although not to such an extent, predictable as the data (50m and 25m resolution) does not detect small changes in elevation to the extent required for stream flow generation in very flat terrain. Therefore it is important for the user to recognize the following:

- Incorrect stream arcs will be generated as part of this process, particularly in flatter terrain. Once analysis has been completed, the generated streams network should be examined visually to determine if any other results have been affected by erroneous arcs.
- Streams generation is an interim fix, to be used until a corrected streams network for the analysis area has been developed.

2.2.3 Plot Locations

Plot locations are the points at which stream and watershed analysis such as gradient and basin area will take place. The first step the application takes when calculating plot attributes is to find a point on the stream closest to the original plot location at which it will perform the analysis. This process is referred to as snapping. A search tolerance is set to tell the system how large of a circular buffer should be searched for the closest stream.

The first issue arises if a stream cannot be found inside the buffer. For such instances a field is added to the plot attribute table called "snapped" which will be ".FALSE." in the event a stream could not be located inside the buffer.

The second more significant issue is when plots do not snap to the intended stream. This problem will be immediately identifiable when the user views the drainage basin polygons. Erroneous plot locations will generate basins which are much smaller or much larger than expected. Fixing this problem involves copying the plot to a location closer to the intended stream or moving the original plot. Making a copy may be more desirable if the plot locations are known to be spatially accurate. These editing functions will have to be performed at the command line or using an editing interface such as ArcTools as there are no tools in the application for spatial editing.

2.2.4 Raster Output

As most watershed processing is performed using the raster spatial model (Grid) all resulting datasets have raster characteristics. Specifically, arcs and polygon data are defined by lines which appear "blocky" as they are generated directly from the outlines of cells defining, for example, a drainage basin during the conversion from raster to vector models. This blockiness will vary directly with the cell size selected during elevation grid generation process.

2.2.5 WRNSFMF Input Data

The spatial and attribute data formats required for the generation of a WRNSFMF data file are specified in section 4.3.2. Because the datasets coming into the application are somewhat complex (forest cover, historical cuts, harvest plan), the application is very rigid in terms of acceptable data formats. In other words, if the incoming data is not in exactly the correct format, the WRNSFMF tool will fail.

2.3 Processing Issues

2.3.1 System Intensive Functions

Most of the processing steps in the WAM application are very computer intensive. This is due to the size of the datasets, the complexity of the datasets and the complexity of the processing. Steps have been made since initial development to make the application faster but the processing time remains an issue. The table below illustrates examples of expected processing times for the particularly lengthy processes under the following conditions:

- Dataset covering six 1:20000 mapsheets (approx. 1200 km^2)
- Generating a 25 meter elevation grid
- Processing approximately 60 plots
- A Sun SPARC 10 50 MHz. processor with 48 Mb RAM

Generate elevation grid	5 hrs
Generate stream order routes	36 hrs
Calculate plot attributes	24 hrs

* These times are only estimates and do not take into consideration other drains on the computer system while the WAM application is running.

2.3.2 Grid cell size

Grid cell size is considered an issue as there are means by which the user can change cell size when creating the elevation grid. By allowing the user to increase cell size, significantly larger dataset could be analyzed. But in the same way that DEM resolution affects generated streams so does grid cell size. Generating an elevation grid with a cell size which is too large will cause all resulting processes to loose detail. If the user chooses to change grid cell size, they should be aware if the implications.

2.3.4 Project Area Selection

Project area selection is the first step in processing data in the WAM application. Project areas must be selected due to the shortcomings of the available hardware and the inability of the software to process very large datasets. The issue arising from the project area approach is how they should be defined. There are mechanisms in place to define the area by selecting an existing polygon coverage or by on-screen digitizing. Once an area has been selected, the application finds which watersheds this area overlaps, and extracts the DEM for that area. At this point the user must select an area which encompasses the entire basin area of interest otherwise the resulting output may be incomplete.

Basin area is defined as the area flowing into the next downstream confluence from the plot where the stream order increases by one, and stream source is defined as that point to the longest contributing stream. Both of these results are impacted if the edge of the elevation grid is reached before the next downstream confluence is located. This can be detected by viewing the output basin polygons and looking for polygons boundaries which are coincident with the boundary of the elevation grid. If such basins are detected, the results for these plots should be discarded.

2.3.5 Processing New Points For an Existing Project

The WAM application processes data on a project basis which is defined by a geographic area. As data preparation (generating the elevation grid and building route systems) requires a considerable amount of time, the most efficient method of processing may be to store project data for future use with updated plot location information. If this is the case, problems arise in the naming conventions used to store the output data as datasets with the default names may already exist in the project workspace. There are two ways in which to solve this problem.

- Rename all the existing resultant data. The user should be aware that the system will write only the most recent resultant data to the project status table, and the original name and location will be overwritten with the new run. It is recommended that the user not change the prefix for the output Info tables when running the "calculate attributes" process. When ArcInfo exports coverages it will bundle all Info tables with a common coverage name prefix into the output export file.

  For example if the user were to export the "wam_plots" point coverage, all Info files such as the "wam_plots.monthflow" and wam_plots.sourcepro" will be written to the export file. This allows for simple bundling of coverages and all information relating to that coverage.

- Create a new project and copy the elevation grid and streams network coverage to this new workspace. The new points can then be run without the problem of having more than one resultant dataset in the project workspace.

2.3.6 Order Route System Generation

Route system structures representing stream order must be built on the corrected or generated streams network. This structure is the only way in which the application can measure up and downstream from a given point. This process is an issue because of the significant amount of time it requires to complete.

3.0 Getting Started

3.1 Overview

The WAM application is written to run on a UNIX workstation with Arc/Info software. The Arc/Info Tin and Grid add-on modules are also required. Data mapping and querying should be performed using ArcView software on a PC via a TCP/IP network connection or also on the UNIX workstation.

The application is launched from a command tool window as follows:

unix_prompt:> wam

This command starts Arc/Info and launches the GUI (graphical user interface) in the Grid module.

The remainder of this section describes some of the up-front characteristics of using the application and the resources available for getting help.

3.2 Message Windows

Throughout the application the user is kept informed of process problems and analysis progress through the use of message windows.

Processing is suspended and warning messages are displayed if the user attempts to create data which already exists, or attempts to select input data for a particular process with incorrect structure.

Examples of these message menus are illustrated in section 5.4.

3.3 Help!

The most detailed resource for help on running the application is this document. In addition, there is limited on-line help for the application accessed by pressing the "help" or "?" buttons located on each menu including the main application pull-down menu. The on-line help will describe how to use each option in the associated menu, and in some cases will provide notes on data requirements and potential problems. The user should also have available to them the Application System Guide. This document gives a detailed description of how the application is structured and it's lower level dependencies. Although it is written for the application administrator, there is information contained in it which may be very useful for system troubleshooting.

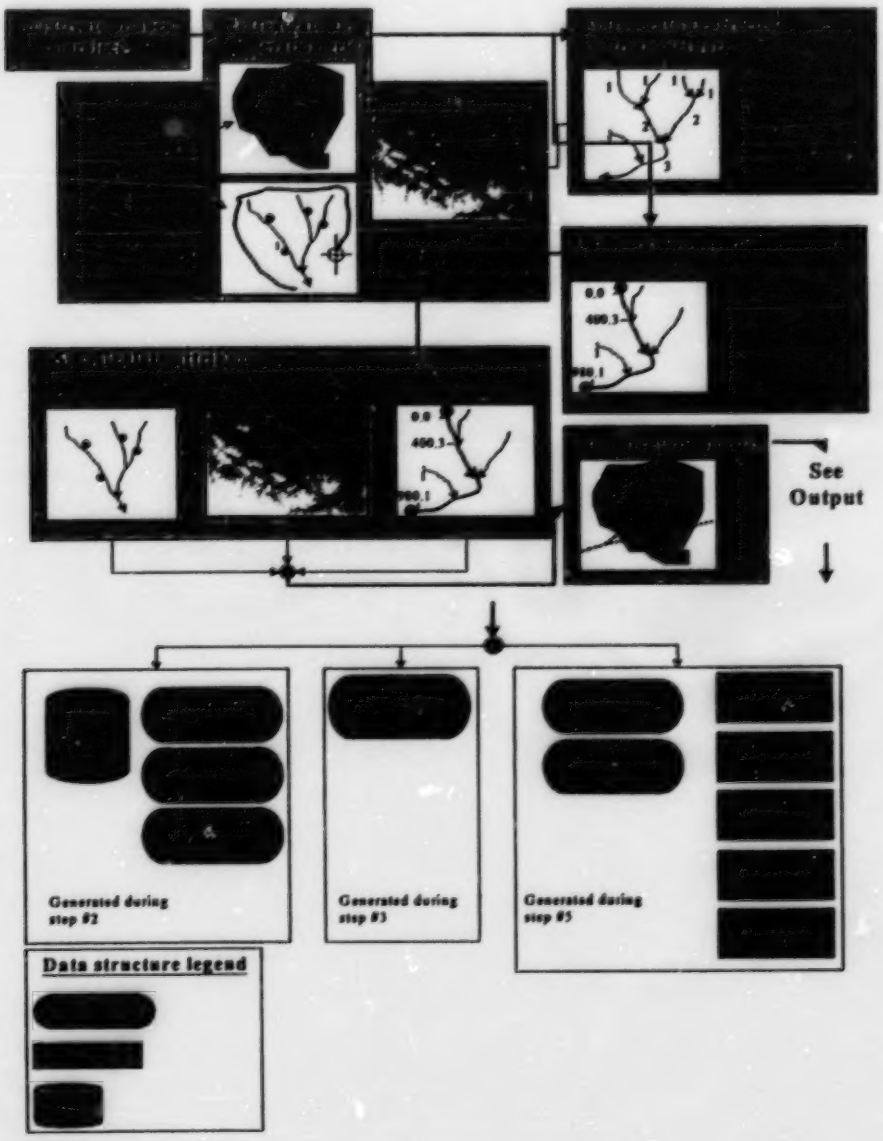
4.0 Process Flow

4.1 Overview

This section illustrates and describes in detail each step of the application process flow. This section is broken up into two parts, the first to describe the steps in generating watershed attribute data, the second to describe the steps in generating a WRNSFMF output dataset. These processes are separated as they can be run independent of one another. But, in order for the application to function correctly all processes must be completed and they must be completed in the correct order.

4.2 WAM Processing

The diagrams below illustrate the WAM processing steps and their output datasets. Each step in the processing corresponds to a textual description starting at section 4.2.1.



4.2.1 Project Management

Projects define processing for a geographic area of interest. Processing is organized in this manner to;

1. Break management areas into pieces manageable in terms of system processing and storage.
2. Prevent confusion between resultant datasets.

3. Allow datasets requiring excessive processing time (elevation grid, generating order routes) to be used more than once.

4. Allow users to run datasets or scenarios without impacting a 'master' dataset.

Projects are defined either by an existing polygon coverage defining the project area, or by way of on-screen digitizing. Users are required to choose a location on disk for the output dataset, a name for the project and optionally a text description of the project. Each new dataset resides in a new workspace (directory) on the workstation as defined by the user, and is created in the selected location on disk.

A record for each project is maintained in a master database. Along with the project metadata the database tracks which datasets have been created by each project. The database is updated as various processes are successfully completed.

The option to delete records from the master project table DOES NOT delete any data from the system, only the record from the table. Data can be deleted using the data management tools.

4.2.2 Generating an elevation grid

The elevation grid is used to calculate basin areas, drainage areas, stream gradient, stream profiles and to generate the aspect, elevation class, and watershed coverages. Although additional calculations not dependant on elevation or aspect do occur, (e.g. sinuosity) they are performed at the same time as elevation dependant calculations and therefore all steps, with the exception of basin density, require the elevation grid as input.

Elevation data is stored in a grid structure to allow direct access for processing that can only be performed using Arc/Info Grid functions. Another reason to store elevation data in a grid format was to accommodate the utilization of the ANUDEM algorithm in Arc/Info's 'Topogrid' command to generate the elevation grid. This command specifically generates a hydrologically correct elevation grid for watershed analysis. The application also uses several other native Grid functions to improve the resulting elevation grid by filling spurious sinks and peaks in the surface model.

The generation of the elevation grid requires an area of interest polygon either selected on-screen by the user or selected as a polygon coverage defining the project area. The application finds which watersheds the area of interest overlaps then buffers those watershed polygons to ensure complete coverage. See section 2.3.4 for more issues relating to project area selection. The application then extracts the required DEM data structures and builds the elevation grid.

4.2.3 Generating a Corrected Stream Network

If the user does not have a corrected stream network for the project area, one can be generated from the elevation grid. The resulting coverage will be composed of connected arcs flowing in a downhill direction and every arc will also be attributed with a stream order based on the Strahler or Shreve methods.

The algorithms used to perform this task identify cells which have more than a specified number of cells 'flowing' into them. This number of cells is referred to in the menu system as the 'flow tolerance' and can be changed depending on the result desired. Selecting a higher number of cells will result in a less dense stream network, while a lower tolerance will result in a more dense network.

4.2.4 Generating Stream Order Route Systems

In order for the application to measure distances along streams, and more importantly measure distances along stream with a common order, it is necessary to build 'route' systems on the streams network coverage. Route systems are an Arc/Info spatial model allowing a single linear feature represented by many arcs to be stored as a single feature. The application uses routes to

store a segment of stream of identical order and to store the segment of stream from the plot location to the source of the stream.

This step in the data preparation process is currently very system intensive. See the section 2.3 for further discussion on route system building.

4.2.5 Attribute Calculation

With the exception of the 'feature density' calculation, all other calculations are performed in this step. This approach was taken to simplify the job of the user by requiring only one step instead of four or five. The down side of this approach is longer processing time depending on the number of sample points.

The following processes are completed during this step:

- Snap plots to point on closest stream
- Calculate length to source of stream
- Calculate sinuosity of plot buffer and to the stream source
- Calculate stream gradient on buffer
- Generate stream profile for buffer and to the stream source
- Generate drainage area and basin area polygon coverage
- Attach drainage and basin areas to plots
- Calculate flows at each plot location*

* It is very important that the user be aware of the source of all stream flow related data. These results are calculated from flow equations derived from monitoring stations. See the WAM final report for details on the "Hydrologic Operational Manual" for applicatility of results to other sites.

For a full description of output datasets see the section 4.4.

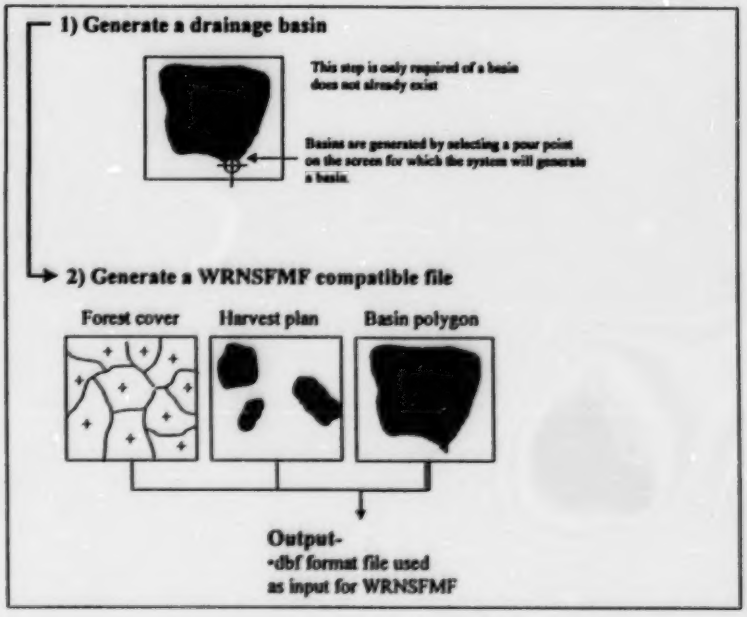
4.2.6 Feature Density

The feature density function allows the user to retrieve any line or point theme, and overlay it with the basin polygon coverage generated during the "attribute calculation" step. The system writes the density for the selected theme features within each basin back to the point attribute table in a user specified field. For linear features it will generate a length value, and for point features it will generate a frequency value.

The user must select the basin coverage associated with the correct plot point coverage (i.e. there is a 1:1 relationship between points and basin polygons). If these datasets do not match, this process will fail.

4.3 WRNSFMF Process Flow

The diagrams below illustrate the WRNSFMF dataset creation process flow and its output dataset.


1) Generate a drainage basin
This step is only required of a basin does not already exist
Basins are generated by selecting a pour point on the screen for which the system will generate a basin.
2) Generate a WRNSFMF compatible file
Forest cover
Harvest plan
Basin polygon
Output-
•dbf format file used as input for WRNSFMF

4.3.1 Generate a Drainage Basin

One of the required input datasets for the WRNSFMF process is a single bounding drainage area polygon coverage encompassing the area of harvest for calculating water yield change. The basins coverage generated during the attribute calculation process is not acceptable for use with the WRNSFMF process **unless** it contains only a single polygon from processing with a single point.

This function allows the user to create the required basin by selecting a pour-point, then viewing reference themes in the background to ensure the generated coverage is encompasses the required area.

4.3.2 Generate WRNSFMF Data File

This step requires that the user select the required input, forest cover, harvest plan , and basin area. The user must also select the output DBF format file which is to be created.

The following table defines the fields required for the input coverages.

Forest cover	ht (representing stand height) spl (representing primary species)	N (actual height) C (according to Weldwood domains)
Harvest plan	Yrcut (representing year of cut)	N (four digit year)

4.4 Application Output Data Descriptions

All processes performed in the WAM application generate new output datasets. Most of the new data such as the elevation grid, are straight forward, but other datasets, particularly that which is generated during the attribute calculation is more complex. The following table describes the default name of the resultant data and it's structure. All Info table structures and item definitions are also listed in the Appendix A.

[illegible]	[illegible]	[illegible]
<wam_elevclass>	Polygon coverage	• Polygons representing 50 meter elevation classes
<wam_aspect>	Polygon coverage	• Polygons representing four cardinal aspect classes (N,S,E,W)
<wam_streamord>	Line coverage	• Corrected streams coverage generated from elevation grid • Route system "order" representing stream order
<wam_plots>	Point coverage	• Copy of input plot coverage with all attributes on the PAT • Additional field "wam_key" can be used to link to all additional Info tables and coverages
<wam_plots>.buffpro,	Info table	• Stream profile table for plot buffer • Up to 100 sample points (ArcView limitation) for each input plot (wam_key) • Sample length (distance) is set for all streams based on longest stream divided into 100 sample points (max_length / 100)
<wam_plots>.sourcepro	Info table	• Stream profile table for plot to source of stream • Up to 100 sample points for each input plot (wam_key) • Sample length (distance) is set for all streams based on longest stream divided into 100 sample points (max_length / 100)
<wam_basins>	Polygon coverage	• Polygon coverage with region sub-classes representing drainage area and basin area • Region subclass "drain" (see glossary definitions) • Region subclass "basin" (see glossary definitions) • Each region subclass feature table (e.g. wam_basins.patdrain) will have a "wam_key" which acts as the key back the output plots coverage (wam_plots) and all other resultant datasets.
<wam_plots>.floodvol	Info table	• Flood volumes at each plot as calculated from Hydrologic Operational manual
<wam_plots>.peakflow	Info table	• Peak flows at each plot as calculated from Hydrologic Operational manual
<wam_plots>.monthflow	Info table	• Monthly flows at each plot as calculated from Hydrologic Operational manual

5.0 Forms

5.1 Overview

The forms that the user sees while the application runs are shown on the following pages. Each page contains comments on what functions are attached to the various buttons and fields. The title of each page corresponds to the menu name described in section 5.4.

5.2 Generate Watershed Attributes

Step	Task	See Menu Titled:	Action
1	Define a project	New Project	• Type in a project name, - no spaces between characters • Type in name for new workspace, - it can not already exist • Type in a project description - this is a free text field • Select a location for the new workspace to be created
2	Generate an elevation grid	Elevation Grid	• Select a polygons coverage covering the area for which to create an elevation grid OR • Select the area graphically • Type in names of output datasets if different from defaults • Check 'view results output' to view results, once complete, in a display window. • Change grid size if different from default
3	Build streams network	Stream Coverage	• Select elevation grid • Select output coverage name if different from default

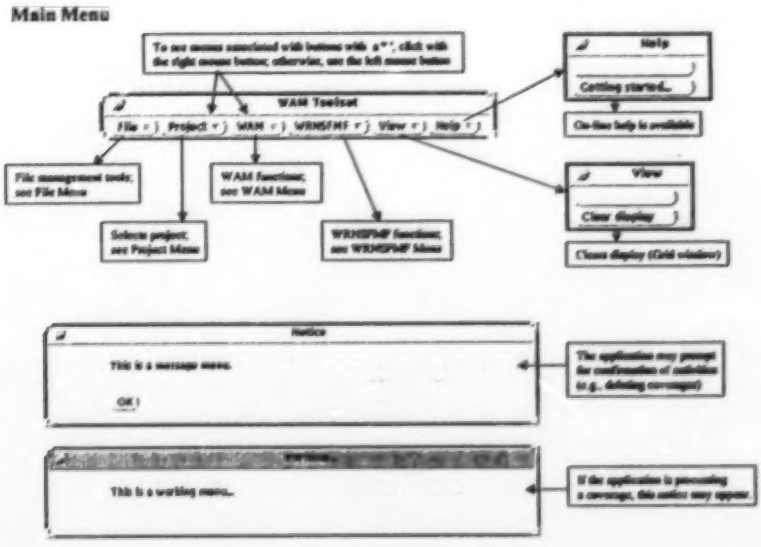
Step	Task	See Menu Titled:	Action
			• Select pout point tolerance • Select stream ordering method
5.	Build stream order route systems	Stream Order Routes	• Select streams coverage
6.	Calculate plot attributes	Plot Attributes	• Select plot point coverage - The coverage CAN reside in another workspace • Select streams coverage - The coverage CANNOT reside in another workspace • Select elevation grid - The grid CANNOT reside in another workspace • Select stream search snap tolerance • Select plot buffer distance • Type in output dataset name if different from defaults
7.	Calculate feature density	Feature Density	• Select a coverage containing features feature for which to calculate density • Select density feature type • Type in new item to be placed on the plots coverage point attribute table if different from default. • Select input basin coverage • Select input plot coverage - The basin and plots coverage MUST be the results of the same 'calculate attributes' run in order that there is a 1:1 relationship of plots to basins!

5.3 Generate WRNSFMF data file

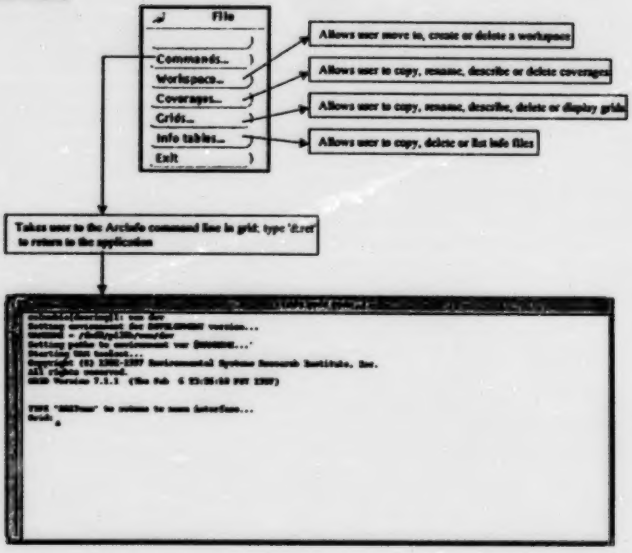
Step	Task	See Menu Titled:	Action
1	Generate a drainage area (if necessary)	WRNSFMF Drainage basin	• Select elevation grid • Type in output coverage name if different from the default • Graphically select a point on the screen for which to generate a drainage basin • If desired, draw reference themes in the background to ensure the area required has been covered.
2	Generate WRNSFMF data file	WRNSFMF	• Select basin coverage - The basin must be a polygon coverage with a single polygon representing the drainage area for the desired WRNSFMF run. The 'wam_basins' coverage generated by the WAM processes CANNOT be used for this task.

Step	Task	See Menu Titled:	Action
			• Select elevation grid • Select a harvest plan coverage • Select a forest cover coverage • Type in a scenario description • Type in the output dbf file name if different from default.

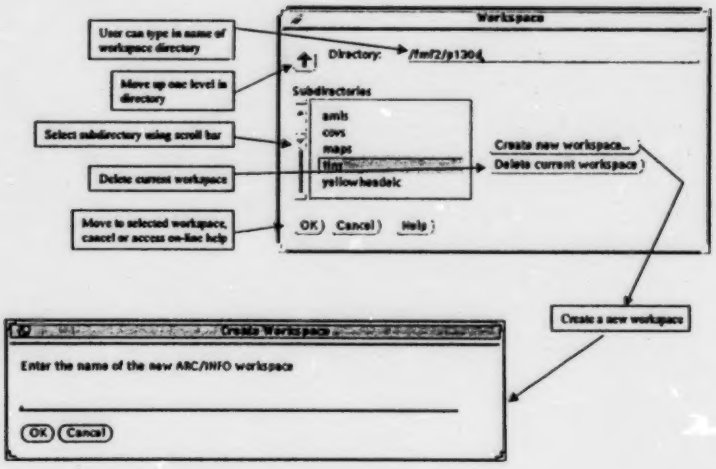
5.4 Interface Menus



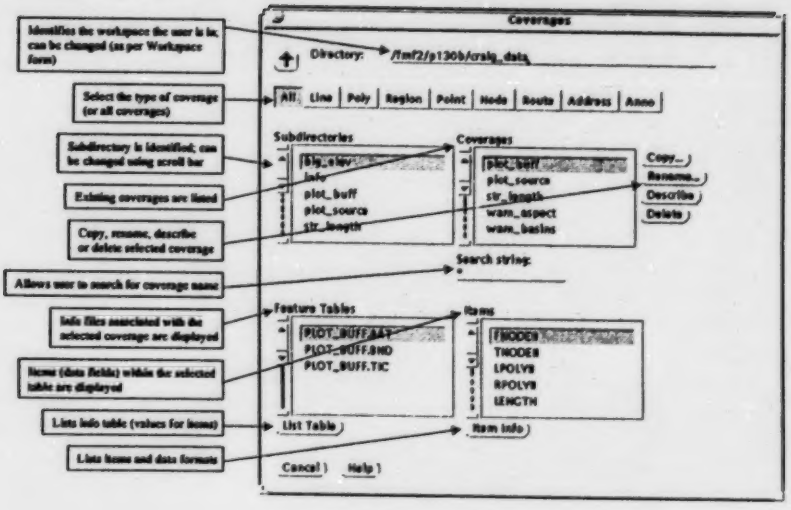
File Menu


File
Commands...
Workspace...
Coverages...
Grids...
Info tables...
Exit
Allows user move to, create or delete a workspace
Allows user to copy, rename, describe or delete coverages
Allows user to copy, rename, describe, delete or display grids
Allows user to copy, delete or list info files
Takes user to the Arcinfo command line in grid: type 'd,ret' to return to the application

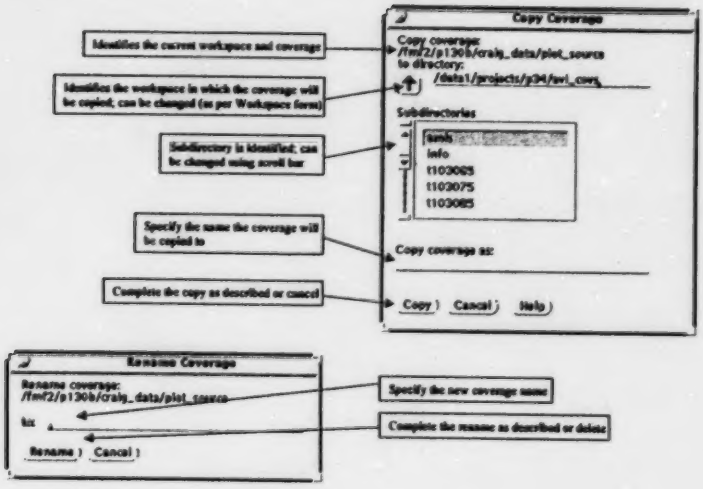
File Menu (cont'd)



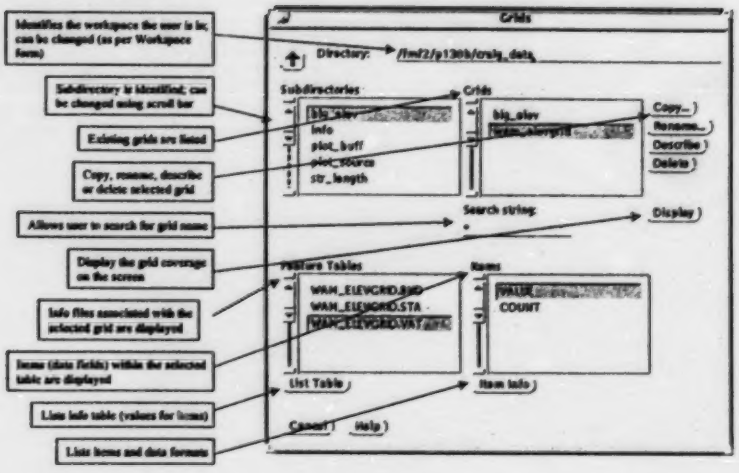
File Menu (cont'd)



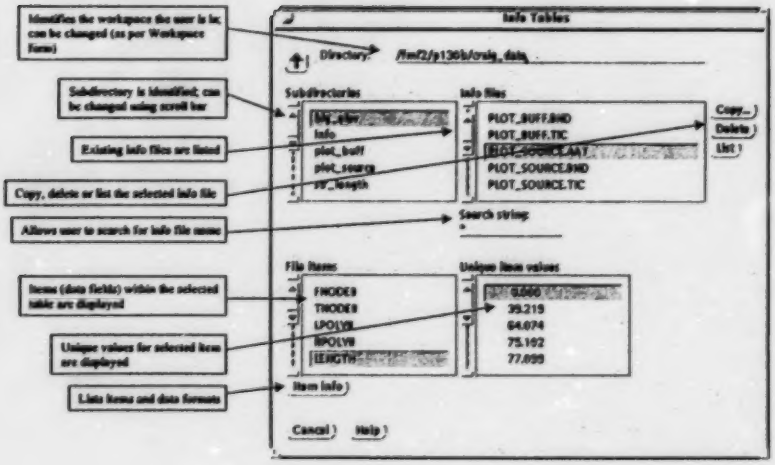
File Menu (cont'd)



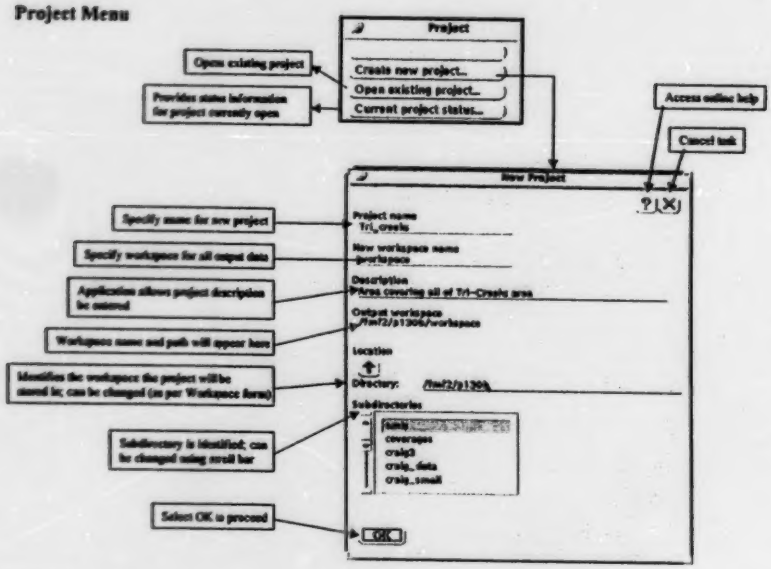
File Menu (cont'd)



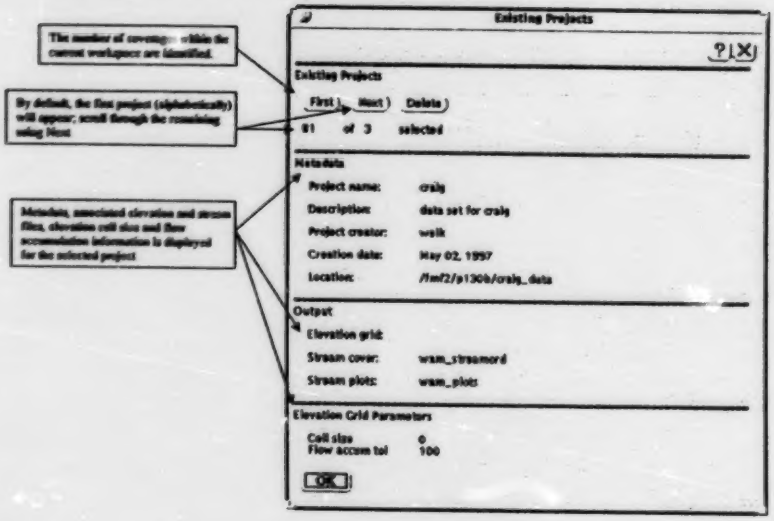
File Menu (cont'd)



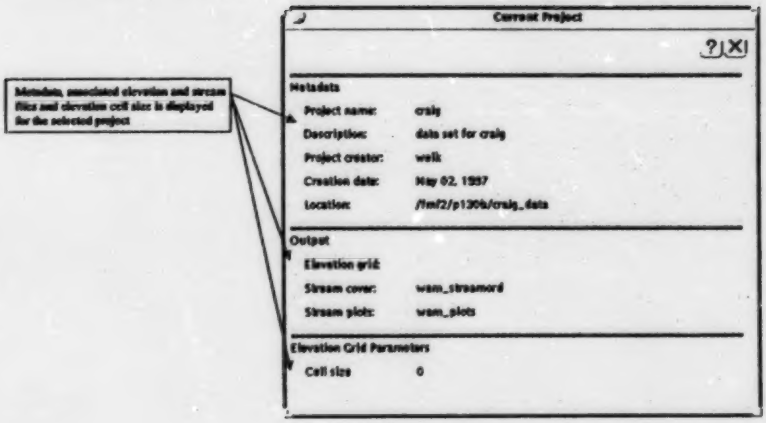
Project Menu



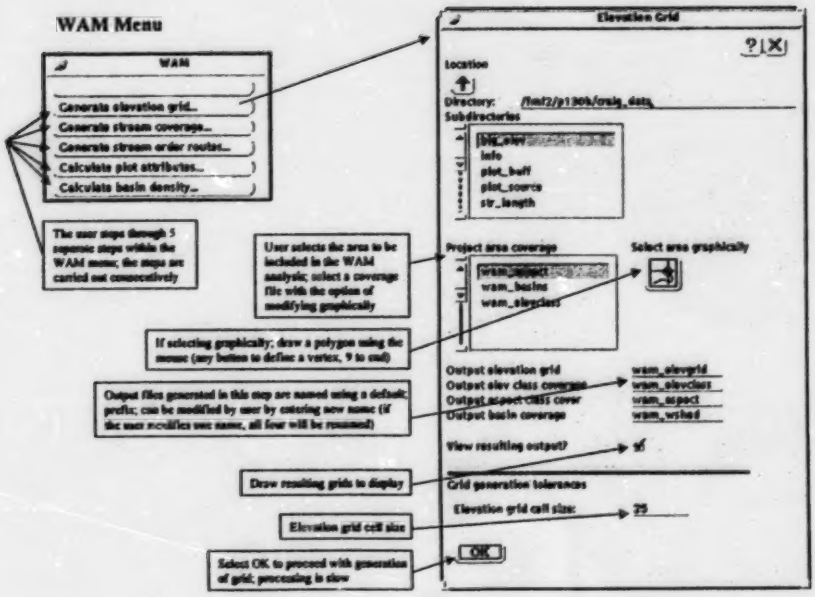
Project Menu (cont'd)


Existing Projects
The number of coverages within the current workspace are identified.
By default, the first project (alphabetically) will appear; scroll through the remaining using Next
Metadata, associated elevation and stream files, elevation cell size and flow accumulation information is displayed for the selected project
Existing Projects
First
Next
Delete
81 of 3 selected
Metadata
Project name: craig
Description: data set for craig
Project creator: walk
Creation date: May 02, 1997
Location: /fmf2/p130b/craig_data
Output
Elevation grid:
Stream cover: wam_streamord
Stream plots: wam_plots
Elevation Grid Parameters
Cell size 0
Flow accum tol 100
OK

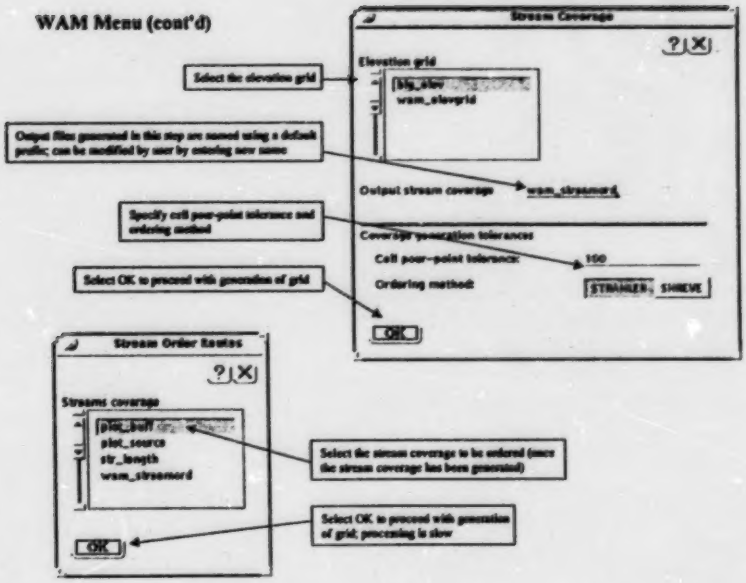
Project Menu (cont'd)



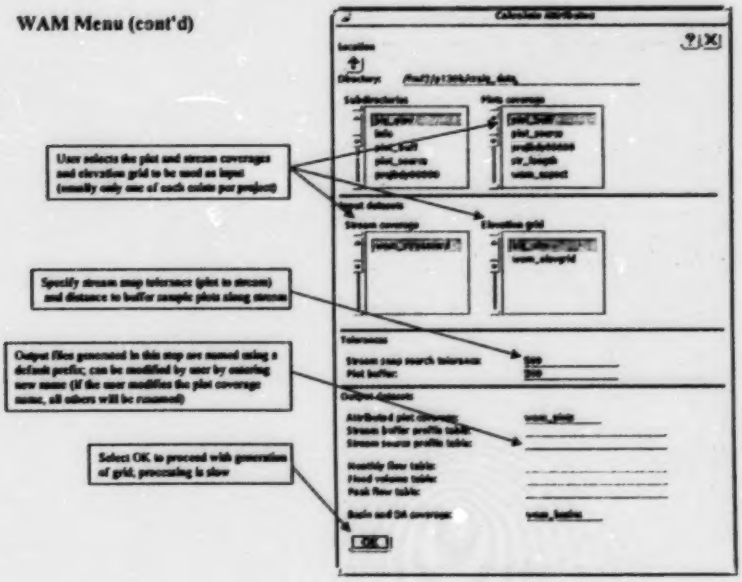
WAM Menu


WAM
Generate elevation grid...
Generate stream coverage...
Generate stream order routes...
Calculate plot attributes...
Calculate basin density...
The user steps through 5 separate steps within the WAM menu; the steps are carried out consecutively
Elevation Grid
Location
Directory: /fm/2/p130k/craig_data
Subdirectories
info
plot_buff
plot_source
str_length
User selects the area to be included in the WAM analysis; select a coverage file with the option of modifying graphically
Project area coverage
Select area graphically
wam_basins
wam_elevclass
If selecting graphically; draw a polygon using the mouse (any button to define a vertex, 9 to end)
Output files generated in this step are named using a default prefix; can be modified by user by entering new name (if the user modifies one name, all four will be renamed)
Output elevation grid
Output elev class coverage
Output aspect class coverage
Output basin coverage
wam_elevgrid
wam_elevclass
wam_aspect
wam_wshed
View resulting output?
Draw resulting grids to display
Grid generation tolerances
Elevation grid cell size:
25
Elevation grid cell size
Select OK to proceed with generation of grid; processing is slow
OK

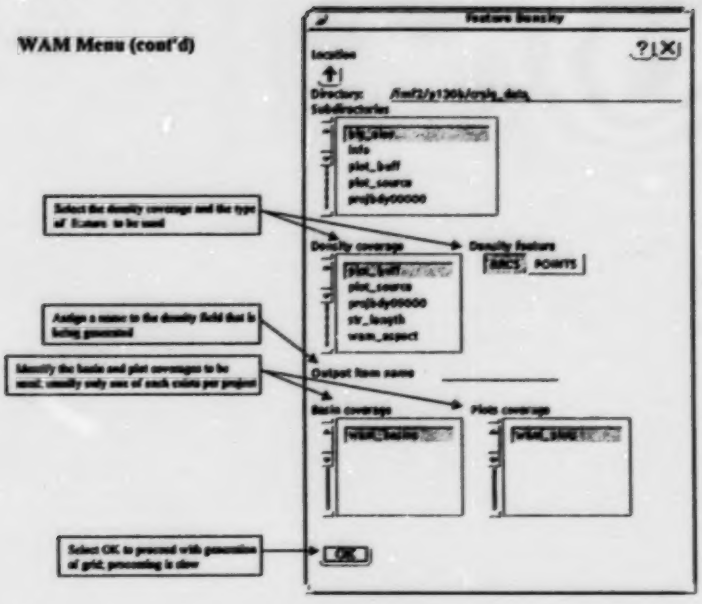
WAM Menu (cont'd)


Stream Coverage
Elevation grid
wam_elevgrid
Output stream coverage
wam_streamord
Coverage generation tolerances
Cell pour-point tolerance:
100
Ordering method:
STRAHLER
SHREVE
OK
Stream Order Routes
Streams coverage
plot_source
str_length
wam_streamord
OK
Select the elevation grid
Output files generated in this step are named using a default prefix; can be modified by user by entering new name
Specify cell pour-point tolerance and ordering method
Select OK to proceed with generation of grid
Select the stream coverage to be ordered (once the stream coverage has been generated)
Select OK to proceed with generation of grid; processing is slow

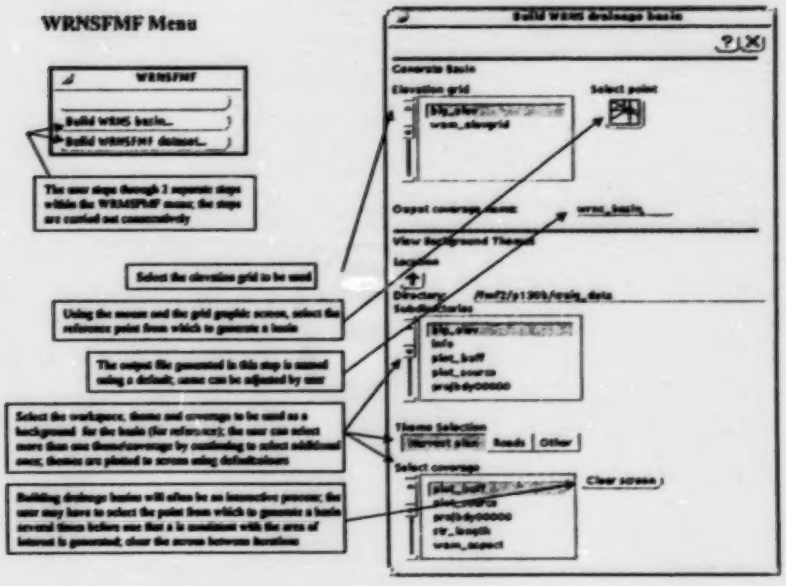
WAM Menu (cont'd)


Location
Directory:
Subdirectories
Plots coverage
Input datasets
Stream coverage
Elevation grid
wam_elevgrid
Tolerances
Output datasets
OK
User selects the plot and stream coverages and elevation grid to be used as input (usually only one of each exists per project)
Specify stream snap tolerance (plot to stream) and distance to buffer sample plots along stream
Output files generated in this step are named using a default prefix; can be modified by user by entering new name (if the user modifies the plot coverage name, all others will be renamed)
Select OK to proceed with generation of grid; processing is slow

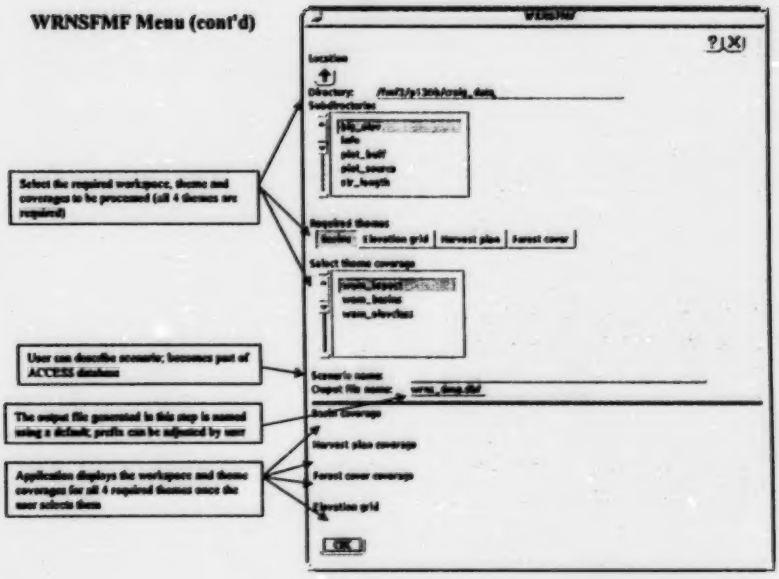
WAM Menu (cont'd)



WRNSFMF Menu



WRNSFMF Menu (cont'd)


Select the required workspace, theme and coverages to be processed (all 4 themes are required)
User can describe scenario; becomes part of ACCESS database
The output file generated in this step is named using a default; prefix can be adjusted by user
Application displays the workspace and theme coverages for all 4 required themes once the user selects them
Location
Directory:
Subdirectories
Required themes
Select theme coverage
Scenario name:
Output file name:
Harvest plan coverage
Forest cover coverage
Elevation grid
OK

6.0 Glossary

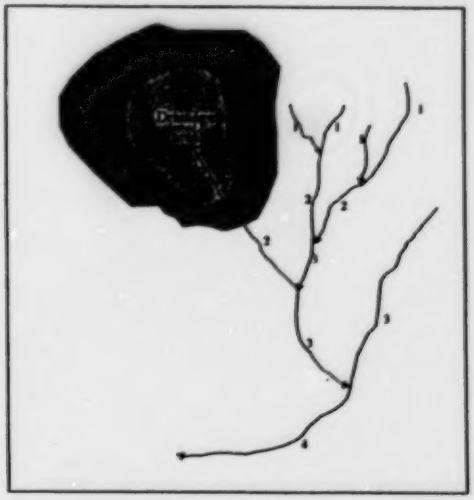
The glossary describes and in some cases illustrate some of the terminology used in describing processes or data in the WAM application.

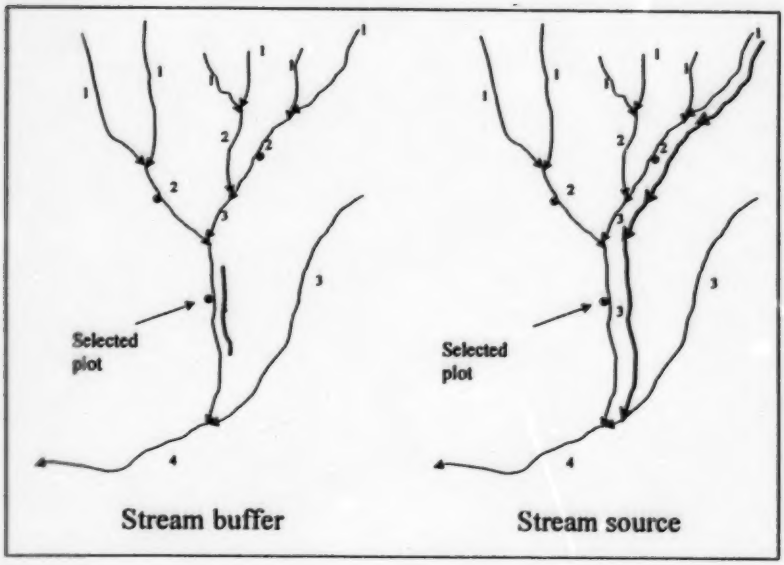
Basin area -

The height of land enclosing the point occurring at the next downstream change in order from a given plot location.

Drainage area -

The height of land enclosing a given plot location.





Stream buffer –

The lineal feature generated when travelling upstream and downstream from a given plot location the specified buffer distance. This lineal feature is then used to calculate sinuosity and gradient for the plot location as well as a profile table.

Stream source –

The lineal feature created by travelling to the next confluence point downstream from a given plot location, and then to the farthest reaching upstream tributary. The farthest reaching tributary is found by moving upstream to the next confluence where the stream order changes. The two or more streams flowing into the confluence are compared for length to the next change in stream order. The longest route to the next confluence is selected and the process is repeated until the end of the network is reached.

This lineal feature is then also used to calculate sinuosity, stream length and generate a stream profile table.

Routes –

Route features are a method of spatial data modeling used by the ArcInfo software to group continuous or non-continuous linear features. The WAM application uses continuous routes for storing multiple arcs belonging to the same stream order.

Events –

Event features are a method of spatial data modeling used by the ArcInfo software to store point or linear features which occur along a given route feature. The WAM application uses linear events to store where a plot location occurs on a given stream and then travels up and downstream the distance of the specified stream buffer. The application also uses events to store the path defining the stream source.

Sinuosity –

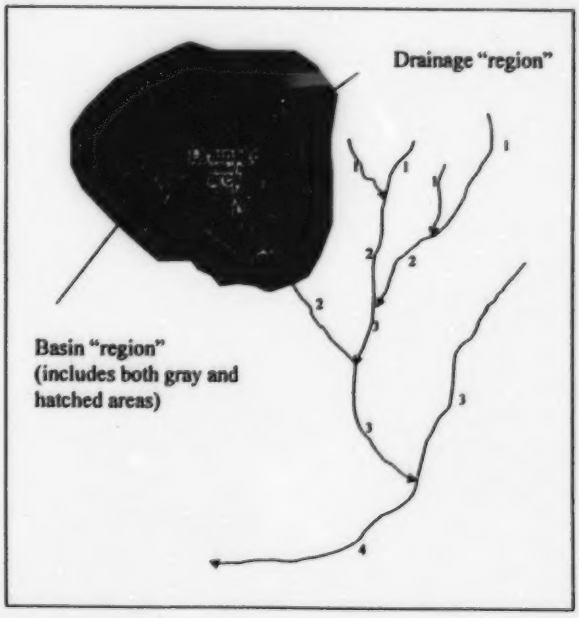
A measure of the number of turns or curves a stream takes. It is calculated in the application as being the actual distance traveled by the stream over the straight line distance. A straight line has a sinuosity of 1.

Gradient –

The measure of the slope of the stream from the upstream point to the downstream point. In the WAM application, the points used for the upstream and downstream measurements are at the ends of the stream buffer. It is calculated as the vertical change over horizontal change.

Regions –

Region features are a method of spatial data modeling used by the ArcInfo software to store continuous, non-continuous and overlapping polygons. The WAM application uses two continuous region sub-classes to store drainage areas and basin areas in the same coverage. This allows the user to view and query individual drainage and basin areas from the same coverage and to retrieve correct area values for each. Using conventional polygons features, each polygon could potentially have to exist on a separate coverage or the user would have to select all drainage polygons inside a given basin when querying for a basin information.



Flow our-point tolerance –

The pour-point tolerance is used when generating the streams network from the elevation grid. The tolerance represents the number of accumulated grid cells which must flow into a single cell in order for a cell to become part of the stream network. The value for the tolerance is inversely proportional to the density of the output streams network .

Corrected streams network –

A corrected streams network is one which meets the following criteria;

- All streams are linked from source to mouth. This includes points where the stream passes through a water body such as a lake.
- All arcs are oriented in the same direction as the stream flow.
- All arcs have an attribute which represents stream order.

Also, it is important that the stream network coincide with the depressions in the DEM which represent the same stream. If this is not the case resulting basin area generation will be effected.

Raster vs. Vector –

Raster and vector are the two methods used by Arc/Info to store spatial data. The raster spatial model stores geographic features by 'draping' a grid of rows and columns over the geographic surface. It then categorizing each cell as to what it represents on the surface.

The vector model stores geographic features by defining their boundaries with points connected by lines.

Point attribute table (PAT)-

An Info database table which contains information tied directly to the spatial point coverage. In the application, most attributes associated with the points (gradient, sinuosity etc.) are stored on the PAT. Arc and polygon features also have similar tables to store spatial feature related information. All of these types of tables are referred to as feature attribute tables.

Appendix A – Output Table Structures

This appendix gives a detailed descriptions of output Info tables.

WAM PLOTS.PAT

AREA	Default ArcInfo item
PERIMETER	Default ArcInfo item
WAM PLOTS#	Internal ArcInfo unique identifier
WAM PLOTS-ID	ArcInfo identifier
FREQUENCY	Application residual
MAX-ELEV ARC	Maximum elevation of arc created from buffer
MIN-ELEV ARC	Minimum elevation of arc created from buffer
MEAN-ELEV ARC	Mean elevation of arc created from buffer
STD-ELEV ARC	Standard deviation elevation of arc created from buffer
XX00006#	Application residual
ORDER#	Application residual
ORDER-ID	Application residual
ORDER	Stream order of stream input plot was snapped to
ARCLENGTH	Application residual
MEASURELENGTH	Application residual
LOWMEASURE	Application residual
HIGHMEASURE	Application residual
FIRSTSECTION	Application residual
LASTSECTION	Application residual
NUMSECTIONS	Application residual
MEASURE	Application residual
BUFFER	Buffer distance up and downstream from the point
UPSTREAM	Distance downstream from the point upstream where the stream order decreases by one to the **upstream** extent of the buffer. A Value of 0 means the upstream extent of the buffer was less than the specified buffer. (e.g. 325 means the upstream extent is 325 meters from the point upstream where the stream order decreases by one.)

DOWNSTREAM	Distance downstream from the point upstream where the stream order decreases by one to the **downstream** extent of the buffer. Downstream - upstream = buffer length, otherwise the full extent of the buffer was not reached.
ELEV_PLOT	Elevation of plot once snapped to the stream
VALUE	Application residual
COUNT	Application residual
ELEV_ARC	Application residual
X_SNAP	X-coordinate of where point was snapped to the stream
Y_SNAP	Y-coordinate of where point was snapped to the stream
XXKEEP	Application residual
WAM_KEY	**Key used to link to all other output datasets including profile tables, stream flows, and basin polygons.**
SIN_BUFF	Sinuosity of plot buffer
LENGTH_BUFF	Length of buffer for all plots in run
STARTX_BUFF	X-coordinate of upstream start point for plot buffer
STARTY_BUFF	Y-coordinate of upstream start point for plot buffer
ENDX_BUFF	X-coordinate of upstream start point for plot buffer
ENDY_BUFF	Y-coordinate of upstream start point for plot buffer
SIN_SOURCE	Sinuosity of stream from source to "mouth"
LENGTH_SOURCE	Stream length from source to "mouth"
STARTX_SOURCE	X-coordinate of upstream start point for stream source
STARTY_SOURCE	Y-coordinate of upstream start point for stream source
ENDX_SOURCE	X-coordinate of upstream end point for stream source
ENDY_SOURCE	X-coordinate of upstream end point for stream source
X_ORIG	X-coordinate of input (and output) plot point
Y_ORIG	Y-coordinate of input (and output) plot point
SNAPPED	.TRUE. or .FALSE. as to if the plot was able to snap to a stream within the specified search tolerance
GRADIENT	Gradient of plot buffer
BASIN_AREA	Area in m^2 of basin area for plot
DRAIN_AREA	Area in m^2 of drainage area for plot
ROADS_LEN	In this case represents the length of road in the plot's drainage basin. This is only an example, this field name is defined by the user when the density is calculated.

Profile tables*

PX	X-coordinate of sample point
PY	Y-coordinate of sample point
SECTION-ID	ArcInfo identifier
SURFACE-ID	ArcInfo identifier
DISTANCE	Distance from start of profile arc
SPOT	Elevation
WAM_KEY	**Key used to link to all other output datasets.**
ELEV_PLOT	Elevation of actual plot. This can be used to find the elevation of the plot in relation to the profile when creating line graphs.

Flood volume flows

WAM_KEY	**Key used to link to all other output datasets.**
AREA	Drainage area in m^2 for elevation class described in next field
ELEV	Elevation class
RETURN_2	2 year return
RETURN_10	10 year return
RETURN_20	20 year return
RETURN_50	50 year return
RETURN_100	100 year return

Monthly flows*

WAM_KEY	**Key used to link to all other output datasets.**
PERIOD	Month
LOW_10	10 year low flow
LOW_5	5 year low flow
MEAN	Mean flow
HIGH_5	5 year high flow
HIGH_10	10 year high flow

Peak flows*

WAM_KEY	**Key used to link to all other output datasets.**
AREA	Drainage area in m^2
RETURN_2	2 year return
RETURN_10	10 year return
RETURN_20	20 year return
RETURN_50	50 year return
RETURN_100	100 year return